

## ULTRASONIC DEVICE IN BONE CUTTING

### *A Histological and Scanning Electron Microscopical Study*

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The immediate and the long-term effects on bone produced by an ultrasonic cutting device and an oscillating saw were compared histologically and by scanning electron microscopy. The long bones and scapulas of rabbits were used as experimental material.

By scanning electron microscopy the osteotomy surface produced by the ultrasonic saw was observed to be rougher than that produced by the oscillating saw, but there were no microfractures. Histologically the early regeneration of the bone tissue was delayed to some degree after ultrasonic cutting, but the regeneration process as a whole was found to be the same after cutting with either of the saws.

*Key words:* bone; bone repair; rabbit; scanning electron microscope; ultrasound

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Several experimental studies have been published on the use of ultrasound in the cutting of bone tissue. In these studies the process of bone repair has been followed by radiographic and histological methods (Mazorow 1960, McFall et al. 1961, Polyakov et al. 1974, Horton et al. 1975). Ultrasound has been in clinical use in the USSR from the late sixties and it has been reported to possess some advantages as compared with conventional tissue cutting methods.

The aim of this study was to compare by histological methods and by scanning electron microscopy the immediate and long-term effects on bone tissue produced by an ultrasonic cutting device and by an oscillating saw. Some technical details will be dealt with in the discussion.

### MATERIAL AND METHODS

Six healthy rabbits of different ages and of both sexes,

weighing 2.5-4 kg, were used. The surgical procedures were performed under sterile conditions. The anaesthesia was induced by a neuroleptic analgetic (Hypnorm®, Philips-Duphar B. V.). In the experiment an ultrasonic saw (URSK-7N, Medexport, Moscow, USSR) (Figure 1) and an oscillating mechanical saw (Stryker®, Stryker-Corp., Kalamazoo, USA) were employed.

To study the immediate effects of cutting on the osteotomy surface, several bone fragments were sawn from the ulnas (Figure 2). A total of eight cut surfaces

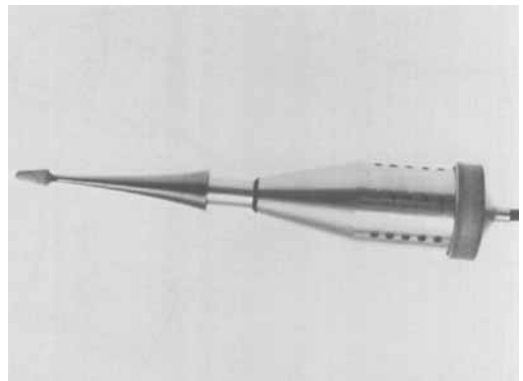


Figure 1. The acoustic unit of the ultrasonic saw with the cutting blade.

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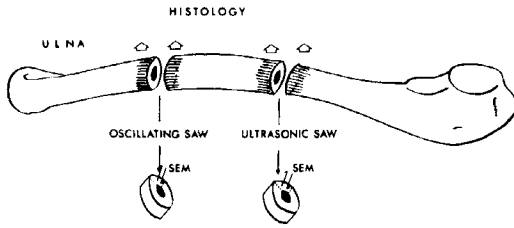


Figure 2. A schematic illustration showing the parts of bone used in the histological and SEM examinations to study the immediate effects of sawing.

were examined histologically and four by scanning electron microscopy. To study the effects on periosteum, scapulas were exposed leaving the periosteum intact on the inner bone surface and grooves were sawn in the crests (Figure 3), four grooves for the histology and four for scanning electron microscopy.

For the regeneration study grooves were prepared in the cortex of six tibias using both the ultrasonic and the oscillating saw. The rabbits were killed 2, 4 and 6 weeks after the surgery with an overdose of Nembutal® (Abbot).

Several 7  $\mu\text{m}$ , formalin fixed, decalcified paraffin sections of the tissue samples were stained with haematoxylin and eosin and with van Gieson and examined histologically.

For scanning electron microscopy the bone fragments were washed with sterile saline and with distilled water, dehydrated in alcohol and dried at room temperature. The osteotomy surfaces were coated with a 200–300 Å layer of gold under vacuum ( $10^{-4}$ – $10^{-5}$  tor). The specimens were examined and photographed with a scanning electron microscope (JEOL JSM-U3).

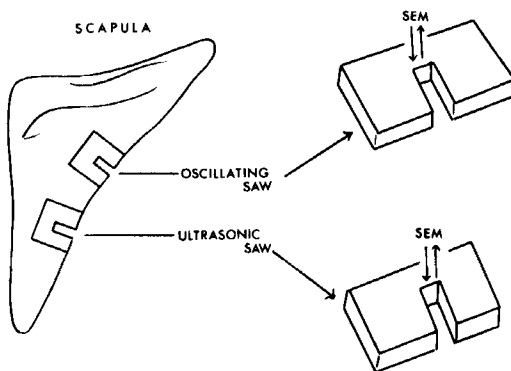


Figure 3. A schematic illustration showing two pieces from the scapula used in SEM examination to study the immediate effects of sawing on the periosteum.



Figure 4. A slightly rough cut surface produced by the ultrasonic saw.

## RESULTS

### Immediate effects of sawing

At the cut ends of the ulnas both saws, especially the oscillating one, tended to cause cortical strips to break off. With scanning electron microscopy the slightly rough surface produced by the ultrasonic saw could be seen (Figure 4) and on the scapulas the periosteum was unevenly raised (Figure 5). The oscillating saw caused a flat surface with parallel grooves and some microfractures (Figure 6). The grinding effect of the oscillating saw was also detected on the scapulas where the edge of the periosteum was rather flat (Figure 7).

In all specimens the cut surfaces produced by ultrasound showed a thin, necrotic layer, which stained less intensely than those cut with the oscillating saw. On the other hand, empty lacunas of osteocytes were observed in the border zone of the cut surfaces produced by both saws and there were no major differences between the two methods in this regard.

### Regeneration

Two weeks after surgery the grooves on the tibias produced by both saws were filled with connec-

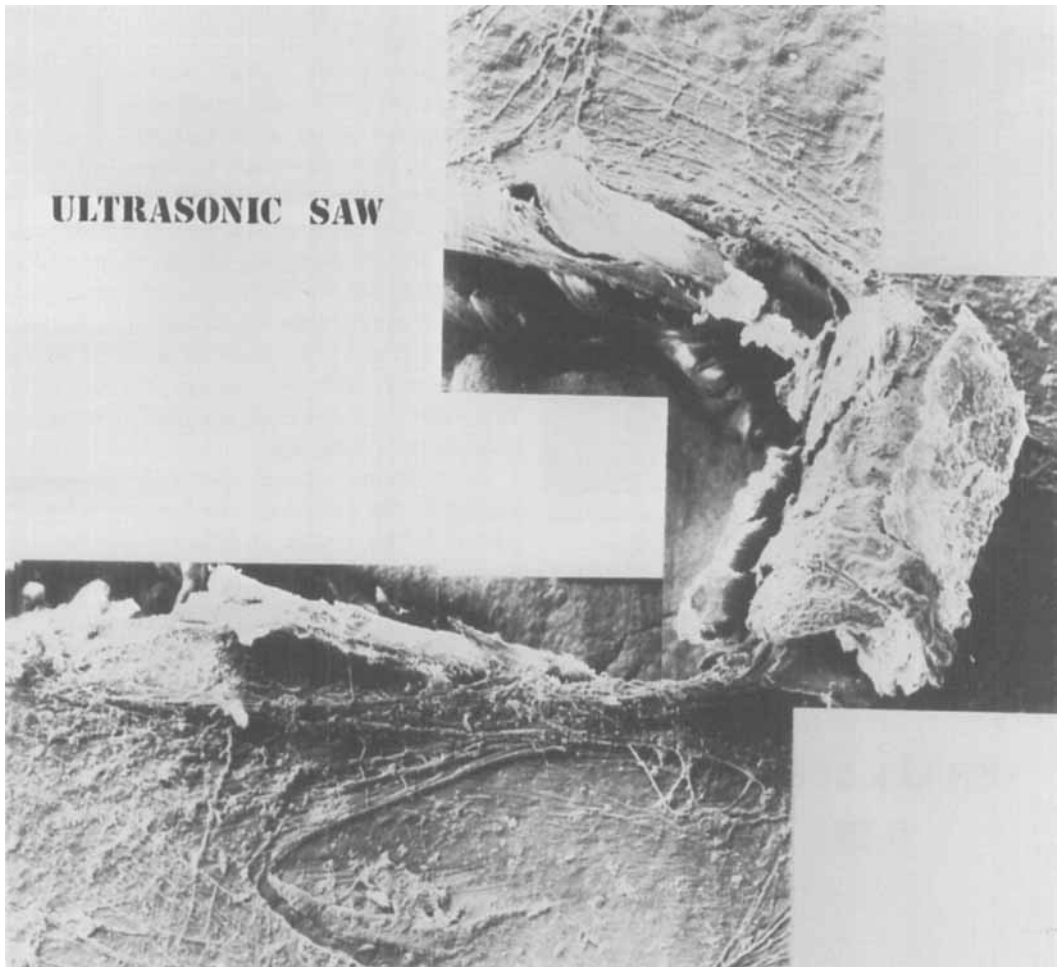


Figure 5. Groove in the scapula produced by the ultrasonic saw.

tive tissue. In those made with the oscillating saw also tiny spicules of woven bone were seen.

In the 4-week-old specimens the grooves produced by the oscillating saw were filled with woven bone (Figure 8), and in some sections some connective tissue was observed. The grooves produced by the ultrasonic saw were partly filled with woven bone and areas of connective tissue were observed in the deeper regions of the grooves (Figure 9).

Six weeks after the surgery both grooves were filled with woven bone.

## DISCUSSION

Our findings in the course of this study revealed that the use of the ultrasonic saw was not without disadvantages: the apparatus was big and unwieldy, the instrument became overheated during use and it was necessary to regulate the apparatus at the generator to maintain the optimal vibration frequency. On the other hand, the ultrasonic saw was smooth and easy to use and it was easier to perform an accurate osteotomy line. Similar observations were made also by Picht et al. (1977) who used the same apparatus in their experiment. When estimating the sawing speed the

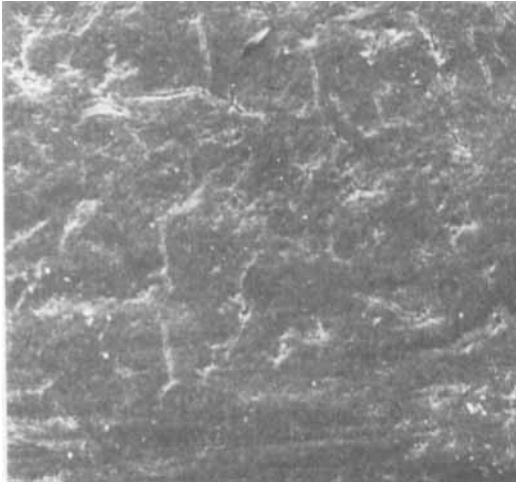


Figure 6. A flat cut surface with parallel grooves and some microfractures caused by the mechanical saw.

oscillating saw was found to be more effective than the ultrasonic saw.

Mazorow (1960), McFall et al. (1961) and Horton et al. (1975) used an ultrasonic apparatus developed for dental use in their studies on bone cutting. In these experiments a few slight differences were observed in the healing rate. Except for the observations of Mazorow (1960) indicating that the ultrasonic saw inhibits the process of bone repair, healing has been found to take place within the normal time limits (McFall et al. 1961, Polyakov et al. 1974, Horton et al. 1975). This is in accordance with our findings although at the beginning healing was slower than after cutting with the oscillating saw.

The different stain reaction of the cut surface caused by the ultrasonic saw has also been reported in the studies of Mazorow (1960) and

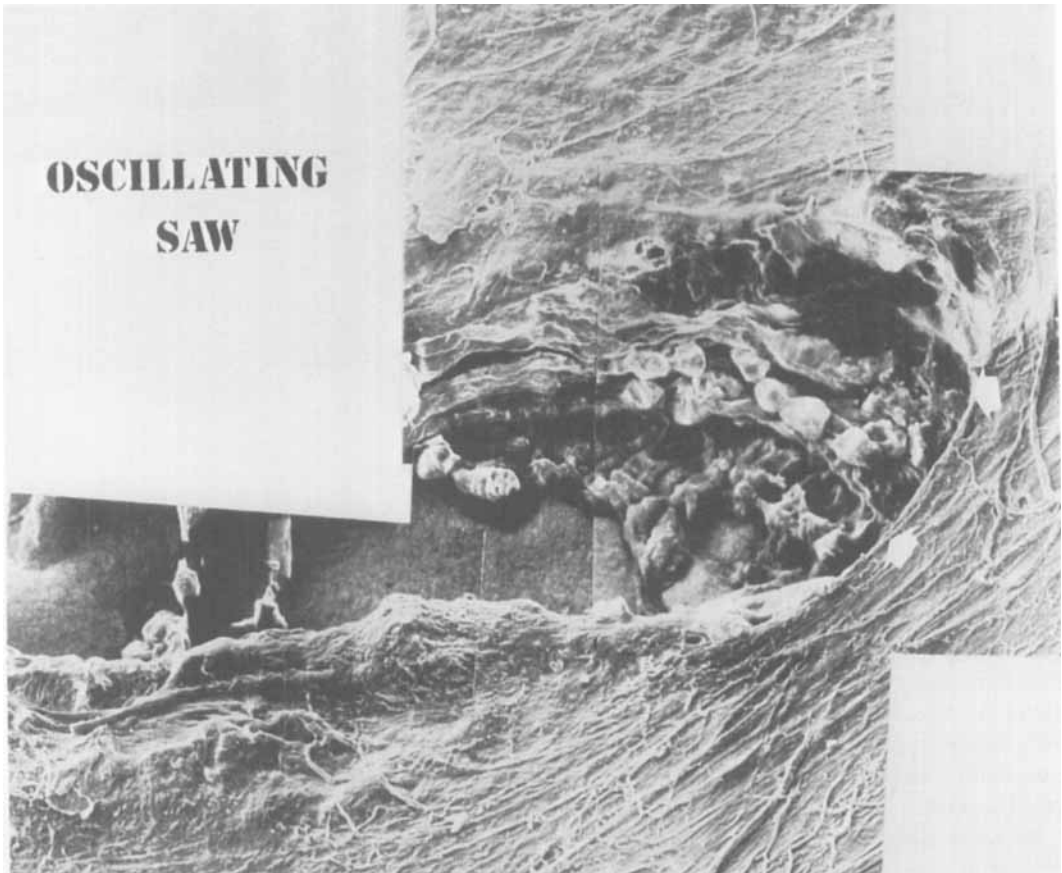


Figure 7. Groove in the scapula produced by the mechanical saw. Arrows show the flat edge of the periosteum.



Figure 8. A groove produced by the mechanical saw is shown, 4 weeks after surgery, filled with woven bone (H & E, Orig.  $\times 40$ ).

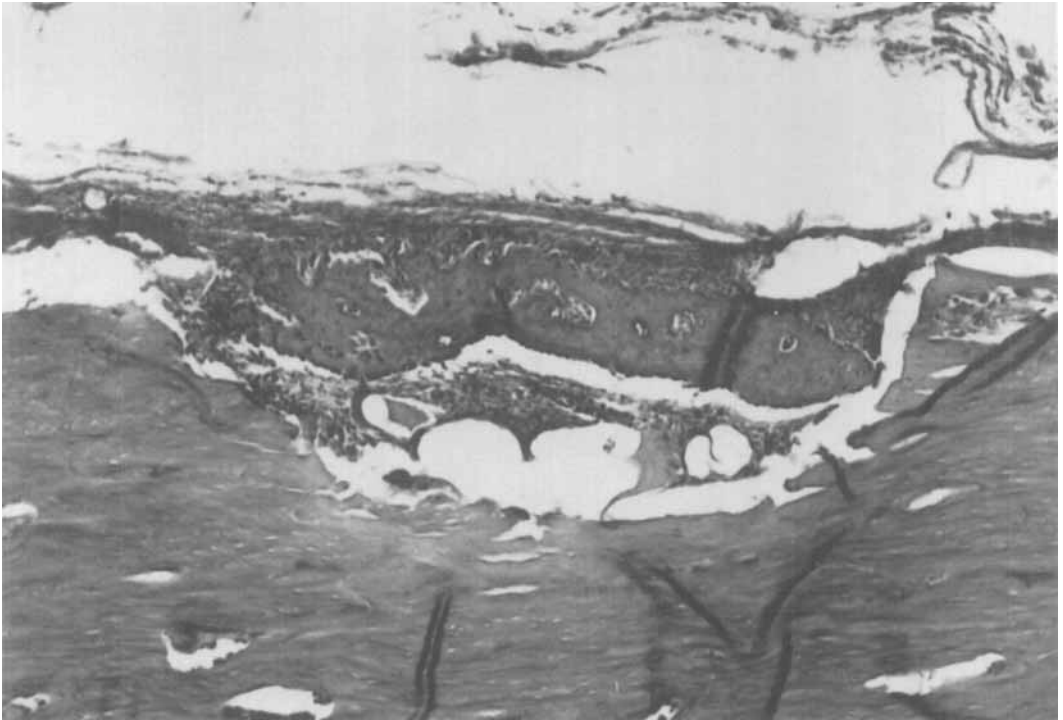


Figure 9. A groove produced by the ultrasonic saw is shown, 4 weeks after surgery, filled with woven bone and connective tissue (H & E, Orig.  $\times 40$ ).

Horton et al. (1975). According to Horton et al. the reaction reflects the heat effect on bone generated during cutting. Picht et al. (1977) reported a temperature of 150°C at the cut surface caused by the ultrasonic saw without cooling; by comparison the oscillating saw produced a temperature of 60°C. Because cooling lowered the heat produced by the saws to about 40°C, Picht et al. (1977) found it necessary to use cooling during cutting. This opinion was also supported by McFall et al. (1961) and Horton et al. (1975). On the other hand, Polyakov et al. (1974) stated that the temperature produced by the ultrasonic saw without cooling did not exceed 78°C.

The character of the cut surfaces have previously only been observed macroscopically. Mazorow (1960) and Horton et al. (1975) reported that the ultrasonic saw left a rough surface, whereas according to McFall et al. (1961) and Polyakov et al. (1974) the surface produced was smooth. In the present study the cut surface made by the ultrasonic saw was observed by scanning electron microscopy to be rougher than that produced by the oscillating saw but it was without microfractures.

In the future, with the development of the technology of the ultrasonic apparatus – a smaller size and easier regulation – it may become a more useful alternative in bone surgery.

#### ACKNOWLEDGEMENT

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